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A PARASITIC AND A PREDATORY ENEMY OF THE FLEA.

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A suggestion of the presence of a parasite on the flea is advanced by Burnett Ham in "A Report on Plague in Queensland" 1900, page 160. He relates the finding of a mite (*Holaspis* sp.), a *Gamasid*, on the brown rat. Ham states that the occurrence of this mite on rats may be accounted for by the fact that it is predatory on insects and may be partial to rat fleas.

There has come to the writer's notice in the literature on American *Siphonaptera*, a single instance of a parasite of a flea. Passed Asst. Surg. Carroll Fox, of the United States Public Health and Marine-Hospital Service, placed on record (Entomological News, July, 1909) a note describing a new mite, the hypopial stage of a *Gamasus*, found on *Ceratophyllus fasciatus* Bosc., the common brown rat flea of San Francisco. Fox, who examined nearly 20,000 rat fleas found but 3 instances of this unique parasitism in *Siphonaptera*. He made an attempt to transfer this mite from flea host to flea, but unfortunately lost the specimen in the attempt.

Prior to the note in the Entomological News, the writer encountered one instance of the flea mite in an examination of thousands of preserved and live specimens. However, since the appearance of Fox's article, 4 specimens were found on a flea (*C. fasciatus*) of the brown rat in San Francisco. These mites, we learned subsequently, were of the same species as that found previously by the writer. Fox, who compared these mites with those he collected, found that they differed essentially. The mite described by Fox has shorter tarsi and there are fewer bristles on the legs. It is on the average somewhat smaller in size and less globular in form than that observed by the present writer.

Mites of the species under consideration have recently been found on fleas collected from squirrels shot in Solano County, 60 miles from San Francisco. Fifteen fleas of the species, *C. acutus*, were found infested. We doubt not that the fleas in squirrel burrows often harbor these mites under natural conditions.

Nathan Banks identified this mite as a member of the *Tyroglyphidae*, a new species of *Histiostoma*, to be described by him under the name of *H. tarsalis*. This acarologist states that most of the

known species have been taken in decaying matter; one, however, in England, was taken from a mole's nest. In his Revision of the *Tyroglyphidae* of the United States (Bulletin of the Department of Agriculture, Technical Series 13) one species of the genus *Histiostoma*, *H. brevipes* Banks, is recorded as occurring on the larva of the locust borer, *Cyrtene robiniae*. The hypopial stage of another of this genus (*H. muscarum*) is recorded by the same author as being attached to house flies. (A Treatise on the Acarina, or Mites. Proc. U. S. Nat. Mus., vol. 28, No. 1382, p. 82.)

For the benefit of the reader we may give here the transformations through which these *Tyroglyphids* pass. This outline we abstract from the work of Banks:

The young, which hatch from eggs, are 6-legged, obtaining 2 more legs at the initial moult. This is the octopod nymph, which may often pass through what is called a hypopus. The body of the latter is hard and chitinous; there is no mouth orifice and there are no distinct mouth parts. By means of sucking disks the hypopus attaches itself to an insect or other creature and is transported to some other locality, where it may find a suitable breeding place. The hypopus is thus a stage in the life of the mite for the purpose of migration. This molts into an octopod nymph, which will feed and develop into an adult mite. The technical description of our new mite we leave to Nathan Banks. A general description, however, may assist us in the present discussion.

The hypopial stage of the mite under discussion is waxy-white in color, nearly translucent, and fairly covered with long moist filamentous bristles, which project from the body and the slender tarsi. In form it bears a striking resemblance to a scale insect. The tarsi, which are unique in this species of mite, are unusually long and delicate. The hind pairs are held nearly horizontal from the body and the anterior ones are extended above the head almost vertically.

The movement of the hypopus is very deliberate and painstaking, and when it is once fastened by the sucking disks to the host it is extremely difficult to dislodge it. The size of these creatures varies but slightly. The average dimensions of 10 specimens were 0.24 mm. long, by 0.14 mm. wide, by 0.06 mm. thick.

The adult mite, which develops in 4 to 5 weeks from the larval form, is an extremely active *Tyroglyphid*, differing markedly from the younger stage. It has 8 well-formed legs, and the mouth parts, in contrast to the hypopus, are powerful and evidently built for piercing. In color the adult is a light yellow with slightly darker legs and proboscis. The average size, taken from the measurements of 10 specimens, was 0.40 mm. by 0.25 mm.

An attempt was made to breed the new mite. For this purpose a flea infested with the mites was placed with 50 noninfested fleas of the same species (*C. fasciatus*) on a brown rat in a cage trap, inclosed in a breeding box of sawdust.

In a few weeks the bedding of the nest was examined and found swarming with minute forms. These tiny creatures bred in such overwhelming numbers that the breeding cages were soon overrun with myriads of the young mites. Particles of food, which dropped to the breeding nests from the wire cages, were literally covered and alive with the *Tyroglyphids*. It was seen, in a short time, that the invaders formed an impediment in the development of the fleas. We found that a large number of the larvæ of the rat fleas had been developed.

These were examined alive microscopically and many adult fleas were likewise inspected. The fleas were observed to be generally infested with the tiny mites, which were found clinging to the spines of the legs and hairs of the body segments. One was seen securely attached to the base of the antennæ. In this breeding cage the greatest number found on one flea was 10, the average number of mites on 200 fleas examined was 3. The flea larvæ were more extensively infested than the adults, the great majority being almost covered. One larva was selected and the mites were counted while the host was under the influence of ether. There were 26 mites, covering the segments of the body and thorax.

These mites have been seen by us on the adult flea (*C. acutus*, *C. fasciatus*, and *L. cheopis*) in various situations. They have been found on all of the body segments, as well as on the legs, especially the posterior pair. One specimen was found in the antennal groove of a male *C. fasciatus*. The antennæ of the flea were projecting, exposing the ear-like groove in which the hypopus was lodged.

The sucking disks of these mites are extremely tenacious. When the fleas are killed by an anæsthetic, the mites do not lose their hold, though apparently stupefied. They are forced to relinquish their perch only when their hosts are put through the process of clearing and dehydrating.

As far as the flea host is concerned, the mites are not a serious impediment, unless they accumulate in numbers sufficient to obstruct the spiracles. When but a few of the parasites are present, the infested flea appears to be quite unhampered by the addition of the hypopus, which moves clumsily from segment to segment until it forms an attachment on the leathery shell of its host. Under these circumstances the normal activities and length of life do not seem to be influenced by the invading mite.

The following table gives the impression that the fleas slightly infested live as long, under the same conditions, as fleas free of mites:

Day.	Fleas with mites.	Fleas used as a control (free from mites).
First.....	22 fleas used.....	17 fleas used.
Second.....	19 fleas alive.....	15 fleas alive.
Third.....	14 fleas alive.....	
Fourth.....	12 fleas alive.....	11 fleas alive.
Sixth.....		5 fleas alive.
Seventh.....		3 fleas alive.
Eighth.....	3 fleas alive.....	2 fleas alive.
Tenth.....	1 flea alive.....	All dead.

These fleas (*C. acutus*), including the noninfested controls, were removed at the same hour from a squirrel kept in the laboratory to serve as a host for the squirrel fleas. In testing the longevity, the insects were segregated into vials and kept in the dark without food. When the infested fleas died, they were examined microscopically and the extent of the infestation was noted. On the 22 fleas under observation the mites were found to average 3, ranging from 1 to 11 per flea.

Although we have taken adult mites of the *Histiostoma tarsalis* from the fleas, we are not prepared to state that the mite is a true parasite, since we have never seen it in the act of feeding. Extreme

infestation proving fatal often occurs however; the best example of this, which has come to our notice, was seen in a specimen of the squirrel flea, *Ceratophyllus acutus*, found in the breeding nest in a helpless condition, unable to jump. At first glance the flea seemed to be sprinkled with a coat of grayish dust particles. These on close inspection proved to be living forms. When examined microscopically, the identity of the flea seemed to be quite lost in a covering of *Tyroglyphid* parasites, which took full possession of every available space. Every segment harbored rows of them; the legs were clothed with them; and the head and rostrum, even the eyes, were covered with the infesting mites. It was apparent that, aside from the additional weight the flea supported, it was rendered helpless through the obstruction of the tracheal system, the abdominal spiracles of which at least were covered by the barnacle-like forms. The flea selected for this study died in 36 hours after removal from the squirrel nest. While under observation, it did not attempt to walk or jump, but lay helpless on its side, struggling occasionally in an effort to free itself from its unwelcome burden.

It was found by actual count that the host in this instance harbored 98 of the hypopial mites. These at the time of death of the *Pulicid* were almost synchronously aroused to action. In bestirring themselves from their inactive condition one would imagine that a state of demoralization had seized them, for they were seen to pry free the sucking disks, loose their perch, and move away from the dead host. When observed through the lens the mites were found to be in various stages of molting; the majority of them were found to be partially free from the scale-like crust of the integument, dragging the cast-off skin by the caudal portion. When the molted skin was examined, it was seen that besides the other appendages, the sucking disks were molted in their entirety. It was also noticed that the hind legs and mouth parts, which heretofore were mere vestiges, were considerably developed. The bristles on the tarsi were shortened in the molt; the bristles on the last tarsi which, prior to the change were longer than the body, appeared now much shortened. In general, the color of the cuticle was changed to a light brown.

The most significant change in the molting process appears to be the correlation of the shedding of the sucking disks with the change of the hypopus to an octopod nymph. It may be stated here that it has occurred to us that the peculiar hypopial stage spent on the body of the flea may be explained in that an attachment is formed for a very active insect, because it is necessary for the mite to get rid of the hard shell of the body before its full development can be attained. Furthermore, we have observed in the study of these *Tyroglyphids* that although other insects like the flies and beetles are present in various stages in the bedding of the breeding cages, the mite appears to strongly favor the fleas and their larvæ.

RÔLE OF A BEETLE IN THE DESTRUCTION OF FLEAS.

We have now to consider another enemy of the flea, inimical to its life in a more direct manner. Live squirrels which were trapped in San Mateo County, when received at the plague laboratory were accompanied in several instances by a species of *Staphylinus* beetle. Several of these beetles were collected with the fleas at the time the

squirrels were combed of parasites. It was noticed in a short time that when the beetles were placed in the vials with fleas the latter disappeared very rapidly. The vials were more closely observed when it was obvious that the beetles were predatory to a striking degree.

The beetle was observed to run aimlessly in an excited manner toward a group of the squirrel fleas, and when a body's length from the nearest flea was seen to rise on the hind legs and with a darting movement pounce on the quarry; then with a snap of the mandibles tear the flea in two. The body of a flea would then be torn to bits, and the invader prepared in a moment to seize the next victim. The movement of springing was peculiarly snake-like, always accompanied by a quick dart of the head. The beetle at each attack would tear and devour a flea until presumably satiated, and then continue to snap at each flea as it appeared in its way, leaving a trail of mangled and dismembered parasites.

In this fashion 5 beetles were observed to render helpless 97 adult fleas in a period of less than five minutes. A single beetle was starved for one day, then placed in a vial with 20 fleas, and permitted to play havoc with the unresisting parasites. In one minute and forty seconds all of the fleas were rendered helpless, either devoured entirely or fatally mangled.

Ten of the *Staphylinus* were retained for breeding purposes. It was found that a diet exclusively of hard-shelled *Pulicids* was not the most favorable for sustaining life, for on the fourth day the fleas no longer appealed to them as an article of diet, and the beetles did not survive the artificial environments presented. Although other insects were found in the material from the squirrel nest, the adult fleas were the only ones selected for attack; as far as we could determine, no instance was observed where the flea larvæ were molested. The rat flea (*Ceratophyllus fasciatus*) was subject to destruction in substantially the same degree as the squirrel flea (*C. acutus*).